and who had followed out the arrangement in many of his churches. Drawings of several of Wren's churches were here exhibited, and the attention to a system of proportion was certainly very remarkable in them, as shown by lines, intersecting the different parts, drawn in red. Mr. Cockerell remarked, that the arrangement of the "temple *in antis*" was adapted to the Christian religion from the symbolic allusions, which might be drawn from it; the three divisions representing the Trinity, and the four columns the four evangelists. He pointed out, that the angles of the different plans were strengthened by projections; and this was in accordance with the directions of Vitruvius, as to increasing the dimensions of the angular column. These large counterforts were to be noticed in many old Roman buildings. He quoted from Cesariano in illustration of these remarks, and in reference to the termination of the chancel or tribune, for which the author gave several forms, but said that the "learned" preferred the square termination, as practised in most English cathedrals. This led to some concluding remarks on the state of learning in the 15th century, which was a state of profound ignorance, and yet high respect and veneration for classical knowledge, illustrative of which he read extracts from Lydgate's Book of the History of the Siege of Troie, in which the architectural splendours of that city were represented under the forms and decorations of the middle ages.

BRITISH ARCHÆOLOGICAL ASSOCIATION.

At the meeting on Wednesday, the 14th instant, referred to last week, Mr. Pettigrew, the treasurer, in the chair, more than fifty volumes of books and pamphlets were presented by various English, French, and German authors to the society.

One of the principal attractions of the evening was a beautiful bronze figure of the goddess Ceres, of exquisite workmanship, sent to the society by the Duchess of Beaufort, with some gems discovered in the excavation of a Roman villa near the ducal residence. Some Roman vessels, and curious round polished stones were also exhibited, on the uses of which, whether for slings, deposited as relics, or for trituration, no positive opinion was given. A very curiously-wrought hilt of a Scottish claymore, with a rude portrait of Prince Charles Stuart upon it, was also exhibited. Mr. Fairholt's careful tracings and drawings, copies from the mural paintings discovered a few weeks since in Carpenters' Hall, London Wall, excited much attention. Several communications of great interest were read, including one by Mr. Croker, from the pen of the Marquis of Worcester, author of the "Century of Inventions," addressed in vain to Charles the Second, for indemnification; he and his father having expended nearly a million of money fruitlessly in the cause of Charles the First; the eccentric marquis alludes to his invention of a water or steam-engine of great and marvellous power.

Mr. Roach Smith read a paper from Mr. Jewit, containing particulars of the ancient hospital of St. Giles, for lepers, at Shrewsbury, and the miraculous virtues of the waters of St. Winifred's Well, in North Wales. Some elucidatory remarks were made by a gentleman present, as to the component qualities of the water, and its freedom from sulphate of lime. The moss from this well of St. Winifred's is, with pious Catholics, to this day considered a specific for many diseases; and the crutches, sticks, and biers still hang suspended among the rich architectural tracery of this picturesque well as trophies of the miraculous effects of its pellucid waters. A long range of mountains, stretching half way from Chester to the sea, are the natural reservoirs and filters of this wonderful spring; and *Moel vamma*, or the mother of the mountains, has more to do than the decapitated head of Winifred, with its vast crystal gurglings. Papers from Messrs. Lower, Rev. Beale Post, Messrs. Prior and Pretty, were in part postponed until the next meeting. Sir William Chatterton, Alderman Moon, and the Honourable Ridley Colborne were received as members.

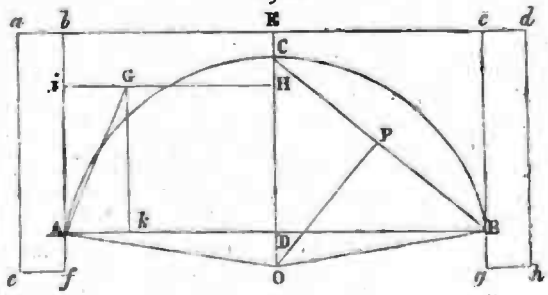
Clandown.—A new church is about to be erected at Clandown, near Bath. The Prince of Wales, as Duke of Cornwall, has subscribed 100*l.* towards the expenses.

ON THE EQUILIBRIUM OF PIERS.

What we have done at page 8 applies to the semi-circular arch when the summits of the piers and the road-way are in the same horizontal plane; but when the arch is some segment less than a semi-circle, the investigation, as well as the construction, is somewhat more difficult, in consequence of the elements which it involves; the general result, however, assumes a form nearly the same as equation (D), and for this reason, the process which it represents will be nearly the same as that just exemplified.

Let ACB (fig. 2), be a segmental arch, of which the span is AB; the versed sine, or height, DC, and CE the thickness at the crown, or the depth of the key-stone; *abfe* and *cdhg* being the upright piers as in the preceding case.

Fig. 2



Draw the straight line BC, which bisect in the point P, and at P erect the perpendicular PO to meet CD produced in O; then is O the centre from which, with the radius OA or OB, the segmental arch ACB is described. Let G be the place of the centre of gravity of the semi-arch ACE*b*, and through the point G let the horizontal and vertical lines iGH and G*k* be drawn, meeting the pier in the point *i*, the axis DE in the point H, and the span or base AB in the point *k*, and draw AG. Then, because G is the centre of gravity of the semi-arch ACE*b*, the whole mass of which it is constituted, may be conceived to occupy that individual point, it will therefore produce the same effect on the pier as is produced by the arch in the actual form of its construction. Now, if G*k* represent the force of the semi-arch in the direction of gravity, then will *k*A represent that part of it which acts against the pier in the direction of the span or base BA; therefore, if *w* denote the weight of the semi-arch ACE*b*, then we have

$$Gk : kA :: w : \frac{w \cdot kA}{Gk}$$

This is the force exerted at the point A to turn the pier about the point *e*, but the leverage on which that force exerts itself is A*f*; consequently, the momentum or mechanical impulse is expressed by $\frac{w \cdot kA \cdot Af}{Gk}$, which must be equal to the momentum of the pier. Now the area of the pier is $bf \cdot ef$, and the leverage is $\frac{1}{2}ef$, so that the momentum is $\frac{1}{2}bf \cdot ef^2$; hence, by comparison and reduction, we get

$$ef = \sqrt{\frac{2w \cdot kA \cdot Af}{bf \cdot Gk}}$$

being precisely the same as equation (A) for the semi-circular arch previously investigated.

Let A denote the area of the semi-segment ACD; then will AD·DE − A, express the area of the semi-arch ACE*b*; and since this is proportional to, and represented by the weight *w*, we have

$$ef = \sqrt{\frac{2(AD \cdot DE - A) \cdot kA \cdot Af}{bf \cdot Gk}} \quad \ldots (E)$$

In this equation the quantities A, *k*A, and G*k* are as yet unknown, but they are all determinable from the data by the rules of mensuration, and a well known property of the centre of gravity; for if we suppose the rectangular plane ADE*b*, to revolve about the side AD, which remains fixed, it will, during the revolution, generate a cylinder whose radius is DE and altitude AD, while the semi-segment ACD generates half a circular spindle, whose radius is DC and half the length AD; and the difference between the cylinder and half the circular spindle, will be equal to the solid generated by the revolution of the semi-arch ACE*b*, and this is equal to a prism whose base is the area of the revolving plane, and altitude equal to the circumference of the circle described by its centre of gravity. Now, by the rules of mensuration, the solidity of the cylinder is expressed by the term 3·1416AD·DE^2, and that of one-half the circular spindle by 2·0944 (AD^3 − 3A·OD); consequently, by subtraction, we get

3·1416 AD·DE^2 − 2·0944 (AD^3 − 3A·OD),

and if this be divided by 6·2832 times the area of the semi-arch, we shall obtain the value of the ordinate G*k* as follows:—

$$Gk = \frac{1{\cdot}5AD \cdot ED^2 - (AD^3 - 3A \cdot OD)}{3(AD \cdot DE - A)} \quad \ldots (F)$$

In this equation we have introduced another quantity whose value is not known *à priori*, but which is readily assignable from the data; we mean the central distance OD, that being necessary for determining the solidity of half the circular spindle.

Again, if we conceive the rectangular plane DA*b*E, and the circular portion DAC, to revolve simultaneously about DE the axis of the arch, and DC its height, the one will generate a cylinder whose diameter is AB and altitude DE, and the other a spheric segment having AB for the diameter of its base, and DC for its height or versed sine, and the difference of these will be the solidity of the figure generated by the contemporaneous revolution of the semi-arch CA*b*E.

By the rules of mensuration, the solidity of the cylinder thus generated, is expressed by the term 3·1416AD^2·DE, and that of the spheric segment by 0·5236 DC (3AD^2 + DC^2); therefore, by subtraction, we get

3·1416 AD^2·DE − 0·5236 DC (3AD^2 + DC^2),

which being divided by 6·2832 times the area of the semi-arch, gives

$$HG = \frac{6AD^2 \cdot DE - DC\,(3AD^2 + DC^2)}{12\,(AD \cdot DE - A)}$$

and by subtracting this from the radius DA or Hi, we obtain

$$Ak = \frac{6AD\,(AD \cdot DE - 2A) + DC(3AD^2 + DC^2)}{12\,(AD \cdot DE - A)} \quad (G)$$

Then, if the values of G*k* and A*k* as represented in the equations (F) and (G), be respectively substituted in equation (E), it will be,

$$ef = \left(\frac{3AD^2(2DE + DC) + DC^3 - 12AD \cdot A}{3A \cdot OD + AD(1{\cdot}5DE^2 - AD^2)}\right)^{\frac{1}{2}} \times \left(\frac{Af(AD \cdot DE - A)}{2bf}\right)^{\frac{1}{2}} \quad \ldots (H)$$

This equation for the thickness of the pier, is more complex in its form than that for the semi-circular arch, and it involves two quantities, that require to be found by a separate computation; these are the central distance OD, and A, the area of the semi-segment CAD, the rules for which may be found in books on mensuration.

In consequence of the very complicated form which the resulting equation assumes, it would be difficult so to express it in words as to render it intelligible to the general reader, but, if the steps employed in resolving the following example be carefully attended to, there will be no difficulty in applying a similar process to any other case.

Example 2.—Let AB, the span or base of the arch ACB, be 100 feet, the versed sine or height DC, 41½ feet, the thickness at the crown or length of the key-stone CE, 6½ feet, and A*f*, the distance from the foundation to the spring of the arch at A, 10 feet; what must be the thickness of the sustaining pier?

In applying the above equation to the resolution of this question, the first thing to be determined, is OA or OB, the radius of the circle, from which is found the central distance OD, and A, the area of the semi-segment CAD. Now BC, the chord of the semi-arc, is equal to the square root of the sum of the squares of the semi-span, and height of the arch; that is BC = $\sqrt{BD^2 + DC^2}$, and the triangles DBC, BOP, are similar; consequently, by the property of similar triangles,

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